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THE ROLE OF DIELECTRIC NOZZLE ON X-RADIATION OF RUNAWAY ELECTRONS DURING HIGH VOLTAGE BREAKDOWN

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Abstract- Present article is dedicated by detection of the role of dielectric nozzle at the potential electrode on X-radiation dose near cathode and anode during formation of nanosecond pulsed discharge in high pressure air. It is shown, that heterogeneity of electrical field and the presence of porcelain cap at the rod with small radius of curvature influents on registration and X-radiation area in atmospheric air. The pressure rise in gas gap reduces to X-radiation near cathode with big radius of curvature in the absence of acrylic resin cap on it.

Keywords: Nanosecond Pulse, Energy, Discharge, Run Off Electrons, Electron Beam, Streamer, Front, Electrical Field Intensity, Propagation Speed, Cathode, Anode, Dense Gas, Solid Dielectric, Electron Detonation.

I. INTRODUCTION

X-ray radiation during the formation of a nanosecond discharge in an inhomogeneous field was investigated in many papers [1, 2]. This issue is of fundamental importance, since the X-rays formed during breaking runaway electrons in the discharge gap, affects the breakdown voltage and the shape of the discharge. In papers [3, 4] reported the registration of X-ray radiation and beam "of runaway electrons in air at atmospheric pressure in microsecond pulses of high voltage. In the studies summarized in review [2] reported the formation of high-power sub nanosecond electron beams when the critical field between the plasma and the anode. The purpose of this paper - to study the conditions of formation of X-ray radiation from a nanosecond volume discharge in the presence of the potential electrode - the cathode dielectric nozzle at high air pressures.

II. THEORY

Our researches were carried out by means of high voltage nanosecond generator by 100 kV with short pulse front about 2 ns (Figure 1). The experiments were performed using a generator of nanosecond pulses, collected under the scheme Arkadyev-Marx. In the experiments, we used a system of electrodes "rod - plane at various radii of curvature of the rod, r=1-4mm. Served as the anode copper plate 1 mm thick. The distance between the electrodes, d=13mm. Air pressure, p in the gas gap was varied: p=1-3 atm. At the core with r=1mm worn porcelain tube - nozzle, whose position was varied with respect to the end of the rod to within 1-5mm. Measurements were carried out only after bombardment of a surface of electrodes by several hundred high voltage impulses.

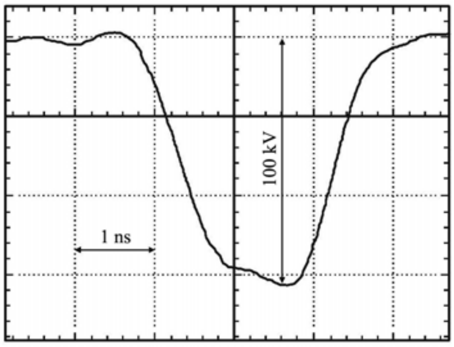


Figure 1. Oscillogram of high-voltage pulse

Figure 2 shows the block scheme of an experimental installation is shown. Impulse voltage was supplied from generator 1 to high voltage electrode - cathode 3 inside the vacuum chamber 2 at atmospheric pressure - P=760 torr and higher. Two cathodes by different curvature radius - r_c ~ 1-6 mm were used. For obtaining the glow of volumetric pulsed discharge at atmospheric and higher pressure a Teflon cap 6 was installed on cathode by diameter 1 mm. As an anode the copperplate 4 and metal netting 5 were used. Inter-electrode distance ~d was changed over the range ~ 3-10 mm. For photographing of the high speed pulsed discharge glow an electro-optical camera 7 was used.

The total current of pulsed discharge was registered by high-frequency oscillograph TDS-5104 by means of current shunt 8. Electron beams current was also registered by oscillograph TDS-5104 by means of Faraday cup and current shunt 9. The cathode and cathode plasma are the sources of runoff electrons in air at atmosphere pressure. Dispersion on gas molecules strongly influences on the space distribution of runoff electrons. In case of pointed cathode the inter-electrode distance – d greatly influences on the width of runoff electrons beam. At increase the - *d* up to 10 mm beam's diameter reaches to ~3cm. If there are some channels in pulsed discharge, that taking place for cathodes with developed surface, the channels quantity are equal to beams quantity in electron stream behind the anode. The streams structure respond to distribution of cathode emitting centers.

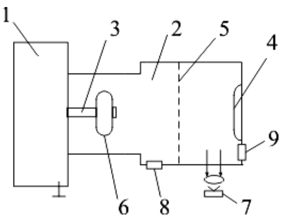


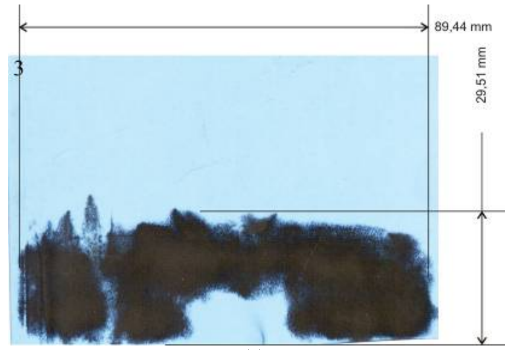
Figure 2. Block scheme of an experimental assembly
1- high voltage nanosecond generator, 2 - vacuum chamber, 3 - cathode, 4 - anode, 5 - metal netting, 6 - fluoroplastic cap, 7 - electron-optical camera, 8 - shunt for measuring of discharge total current, 9 - shunt for measuring of electron beams current.

In some experiments the tube put on cap Teflon rectangular shape, whose position is also varied with respect to the whole porcelain tube within 1-5 mm. At the core with *r*=4 mm worn nozzle Plexiglas rectangular shape, whose position is changed relative to the end of the rod to within 1-5 mm.

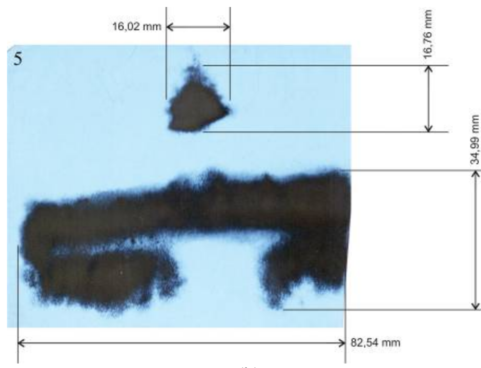
At each configuration, the potential electrode with different dielectric nozzles excited nanosecond discharge in the gas gap and detected by X-ray radiation using a dosimeter DP5V, located at the side of the discharge zone at a distance of 1cm. In contrast to install it with X-ray film cassette CP-BU, this was sensitive X-ray film of high contrast. Autographs X-rays were obtained by continuous repetition of the estimated frequency of 200 kHz. Registration of X-rays on the film showed that only when applying voltage pulses of negative polarity at the potential electrode and the intensity of X-ray photon energy is sufficient for the illumination of the film, placed in black paper (Figure 3). On the developed film also shows the size of area X-ray emission from the cathode and anode.

Figure 3 shows that when using a rod with *r*=1 mm in the presence of a dielectric nozzle on it and without it at atmospheric pressure X-ray radiation is detected at the cathode and the anode (Figure 3-d). In the case of a rod with *r*=4 mm, if it tips out of Plexiglas, launched about the end of the rod at 5 mm, the radiation at atmospheric conditions is detected only at the anode (Figure 3-a). The increase in air pressure - p in the gas gap to 3 Atm, even in the absence of the cathode dielectric nozzle promotes X-ray emission from the cathode and anode, with excitation of the nanosecond discharge.

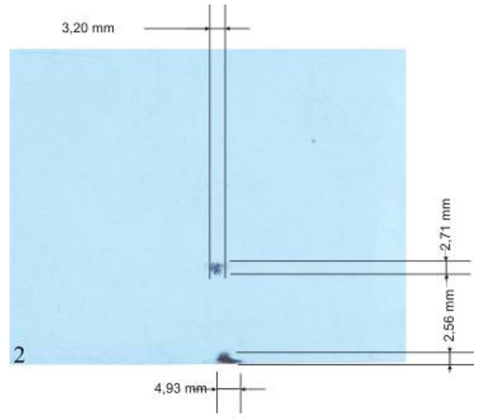
Analysis of the X-ray photographic film of that in the case of a rod with *r*=1 mm (with or without nozzle) at atmospheric pressure in the gas gap critical field strength is reached at the cathode and anode. When pulse on the rod with a sharp front electric field near the cathode increases sharply due to the presence of positive space charge, which leads to explosive processes from micro in homogeneities of cathode.



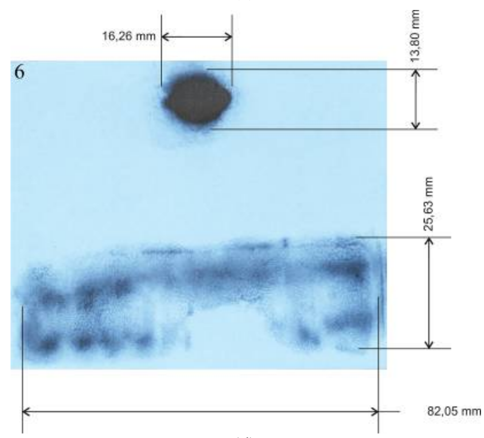
(a)



(b)



(c)



(d)

Figure 3. Autographs X-rays on photographic film placed at a distance of 1 cm from the side of the discharge gap at different air pressures for electrodes - cathode with different *r*, with and without them the dielectric nozzle, *d*=13 mm (inter-electrode distance)
(a) rod (*r*=4 mm), *p*=1 atm, nozzle Plexiglas launched at the end of the rod about 5mm; (b) rod (*r*=4 mm), *p*=3 atm, without dielectric nozzle; (c) rod (*r*=1 mm), *p*=1 atm, without dielectric nozzle; (d) rod (*r*=1 mm), *p*=1 atm, porcelain nozzle unveiled at 5 mm from the end of the rod

Near the anode, the field strength also reaches its critical value, which leads to the formation of an ultra short electron beam, which bombard the anode, is also hard X-rays. If there is a rod (r=1 mm) porcelain tube, launched on its end at 5 mm, the zone of radiation at the cathode and the anode is much expanded (up to 16 mm at the cathode, the anode up to 82 mm). This is most likely due to the distortion of the field at the cathode due to the accumulation of positive ions on the surface of the porcelain tube and hence the expansion of the zone of ionization, which leads to the formation of a large number of avalanches with a concentration of high-energy electrons at the front, bombarding the anode with a total kinetic energy.

III. CONCLUSIONS

The absence of radiation about the rod with r=4 mm, compared with r=1 mm under the same conditions, even if it nozzle Plexiglas can be attributed to a weak in homogeneity of the field at the cathode. An increase in air pressure to 3 atm at the cathode with r=4 mm (even in the absence of nozzle to it of Plexiglas) and is registered at the anode X-ray radiation. This can be explained by an increase in field strength at the potential of the electrode at high pressures. Hereby, by varying the pressure, the size of the electrode and nozzle position relative to the rod end can get a different dose of X-ray emission from the cathode and anode

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BIOGRAPHIES

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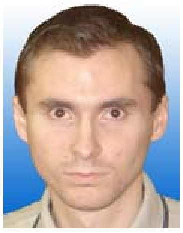

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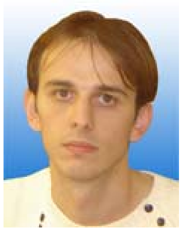

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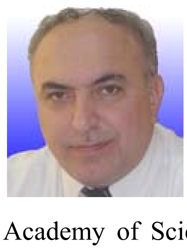

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